Standard for Pervious Paving Systems

Definition

Pervious paving materials include pervious interlocking concrete paving blocks, concrete grid pavers, perforated brick pavers, and compacted gravel.

Note: Porous bituminous concrete is not included in this standard due to concerns about documented high failure rates. Although it may be used successfully in restricted applications, widespread use is not currently advised. Innovative designs incorporating extraordinary operations and maintenance measures and/or improved bituminous concrete technology may be considered by NJDEP on a case by case basis.

Purpose

Pervious paving systems are used to reduce the imperviousness of firm surfaces such as patios, walkways, driveways, fire lanes, and parking areas, for the purpose of reducing surface runoff and increasing infiltration. The pervious paving systems also can used often as inlets and covers for infiltration trenches. Pervious paving can be effective in helping to reduce peak surface runoff rates or in improving the groundwater recharge characteristics of developed sites.

Conditions Where Practice Applies

Pervious paving requires moderately pervious soil with the depth to the seasonal high water table or bedrock of greater than 3 feet below grade. Because of the large area over which infiltration occurs, pervious paving minimizes the potential for groundwater mounding or concentrated discharges to groundwater. For this reason, pervious paving has been used successfully at sites underlain by karst bedrock where other methods of groundwater recharge would not be recommended because the potential exists for sink holes to form.

Because pervious paving recharges surface runoff directly to groundwater, it should not be used where there is a significant concern for the contamination of surface runoff with dissolved pollutants. In particular, to prevent contamination of drinking water supplies, they should not be installed in highly pervious sand or gravel seams that are directly connected to aquifers, or in 'hotspot' drainage.

Pervious paving typically is installed in lieu of or in proximity to runoff-generating surfaces. The best performance is achieved when the up-gradient drainage area is minimized. One strategy is to alternate areas with impervious and pervious paving. In these instances, conventional impervious paving would be reserved for the most heavily trafficked corridors. A wide variety of concrete and brick paving systems are available. These can he combined with conventional pavement to achieve functional and aesthetically pleasing designs.

Pervious paving systems are prone to clogging by suspended solids. To reduce the likelihood of clogging, pervious paving should not be used in areas that receive

significant amounts of sediment, including mud tracked onto the surfaces during wet weather and sand or cinders used in snowy conditions. To preserve the long-term performance of pervious paving, it is important to control sources of suspended solids in stormwater before if runoff is discharged onto the paved surfaces.

Design Criteria

Two factors must be considered when designing pervious paving:

- Runoff collection
- Percolation

Runoff collection is controlled by the infiltration potential of the surface layer (e.g., gravel, brick, or concrete pavers) and by the storage capacity of the paving base. For most pervious paving systems, the surface infiltration rate is large enough that this factor can be ignored as a design consideration. However, the surface infiltration rates of compacted graded aggregate or topsoil may be limiting. The infiltration potential of paving systems that use these materials should be established by field testing. Long-term surface infiltration rates are generally much less than the rates measured on newly installed surfaces. The following table presents typical ranges for long-term surface infiltration rates for a variety of paving materials.

Paving Type	Surface Infiltration Rate (inches/hour)
Pervious interlocking concrete paving blocks bedded in coarse aggregate, no vegetation (15 percent open cell area)	4.5 to 6.3*
Compacted uniform gravel or crushed stone (uniformity coefficient < 2)	2.0 to 6.3*
Concrete grid pavers bedded in sand, surface treatment with topsoil and vegetation (25 percent open cell area)	0.63 to 2.0
Compacted dense graded aggregate (uniformity coefficient >10)	0.2 to 0.63
*Initial infiltration rates may exceed 150 inches /hour	

Pervious paving systems require a porous base. Because of its structural stability and large porosity, uniform (open-graded) crushed stone is preferred as a base material. Water will continue to infiltrate freely through the pervious paving until the voids in the base fill with water. After the base fills with water, the residual surface infiltration rate will be dependent on the permeability of the underlying soil subgrade, which is usually less than the surface infiltration rate. Therefore, it is good practice to design the base layer to store 100 percent of the volume of water that will infiltrate. The depth of the base layer, therefore, will depend on the infiltration requirement for the paved surface. To compute the storage capacity of the base, the porosity of the compacted base material must be known. To preserve the storage potential of the base, a geotextile should be installed between the base and subgrade. The geotextile will minimize the tendency for soil to migrate upward into the base.

Pervious paving enhances percolation to groundwater by:

- Minimizing the evaporation and transpiration (by plants) of infiltrated water
- Sequestering infiltrated runoff until it can soak into the underlying soil

In many instances, pervious paving will be installed in trafficked areas where a stable structural foundation is essential. When the base materials are compacted, the underlying soil is compressed. Therefore, the soil subgrade through which the infiltrated groundwater must percolate usually is less pervious than the undisturbed soil at the site. The permeability of the compacted subgrade must be known or conservatively estimated to evaluate the time required for the water stored in the base layer to percolate, or exfiltrate, into the underlying soil. For proper performance. percolation should be complete within 48 hours. If the subgrade materials do not exhibit adequate permeability, percolation can be enhanced by interconnecting the paving base with an Infiltration Trench (see Figure 2). The soil lining the trench, unlike the paving, does not have to be compacted and usually will have higher permeability. When estimating the time for dewatering of the base, a factor of safety of 3 or greater is recommended to account for reductions in the rate of percolation over time.

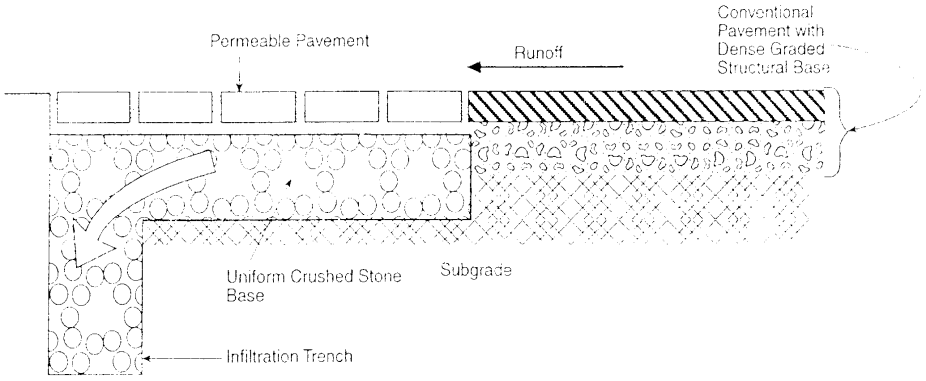

Figure 1. Interconnected infiltration trench under permeable pavement.

Figure 2. Pervious Paving edge and Infiltration Trench Source: Cahill Assoc.

For small runoff volumes that will not completely fill the pore space of the base, the surface infiltration will remain high. For larger runoff volumes, the rate of surface infiltration will decrease abruptly when the base becomes saturated. Therefore, runoff coefficients (or runoff curve numbers) estimated for pervious pavings will depend on the size of the design storm. Comparatively small, frequently occurring storms are most appropriate for establishing design criteria where ground recharge occurs. Appropriate design criteria for pervious paving include:

- Maintenance or reduction of the peak runoff rate below a fixed value (usually the predeveloped runoff rate) for the design storm

- Maintenance of the total annual runoff volume below a fixed value (usually the predevelopment runoff volume)

Pervious paving is not an appropriate control measure for achieving water-quality objectives. However, some treatment is provided by the adsorption, filtration, and microbial decomposition at the base-subgrade interface (Schueler, *et aL,* 1992).

Considerations, Operation and Maintenance

Pervious paving is easier to maintain in areas where access to the paving is limited or controlled and where paving maintenance can be incorporated as part of a program of routine site maintenance. Examples include parking areas for condominium complexes, institutional buildings, office buildings, and commercial facilities. Sand or cinders, commonly used in snow removal operations, should not be used on pervious paving. In many instances, the cost for maintaining pervious pavings will be more than offset by the capital and maintenance costs of stormwater management measures, such as detention basins, that would otherwise be required. A brief description of the characteristics and maintenance requirements for various paving materials follows.

Perforated Brick Pavers and Concrete Grid Pavers

This type of paving is best suited to areas that carry pedestrian or light vehicular traffic. Areas surfaced with pavers can be damaged by snow plows or loader buckets that are set too low to the ground. Therefore, care must be used when removing snow from these surfaces, especially in areas where differential settlement may have caused “lipping” of the pavers. If mud or sediment is tracked onto the surface, it should he swept away as soon as possible.

For best performance and longevity of the paving, the pavers should be bedded in concrete sand. Vegetation that colonizes the open cells or perforations should be removed. Semiannual maintenance to remove vegetation should be adequate. Herbicides that persist in the environment should not be used to control vegetation.

For practical or aesthetic reasons, the designer may choose to fill the open cells of the payers with topsoil and vegetation. In these cases, the vegetative layer must be maintained as any other grassed open area. Deep-rooted woody plants, which can disrupt the paving and reduce permeability, should be prevented from colonizing the surface.

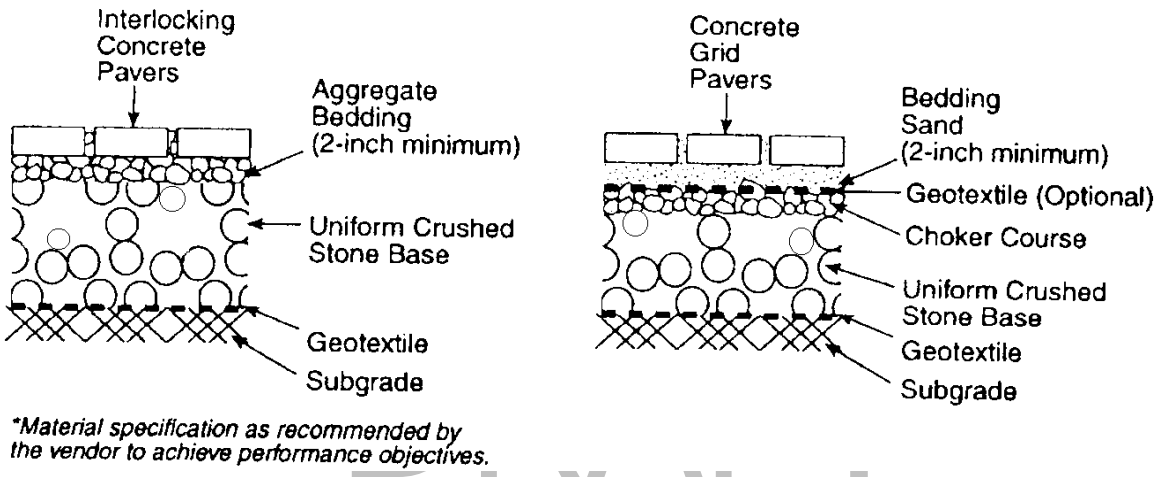

Figure 3. Examples of Pervious Paving

Pervious Interlocking Concrete Paving Blocks

These pavings are designed to accommodate more constant traffic and higher tire loads than concrete grid payers or perforated brick payers. They are comparatively easy to maintain and have long service lives. Pervious interlocking concrete paving systems should be bedded in coarse aggregate. The open cells can be infilled with decorative pea gravel to further enhance the appearance of the finished surface.

Colonization of the open cells by vegetation should be discouraged. Semiannual maintenance to remove vegetation should be adequate. Herbicides that persist in the environment should not be used to control vegetation. If mud or sediment is tracked onto the surface, it should be swept away as soon as possible.

Compacted Gravel

Gravel-surfaced areas are suited to areas with very light vehicular traffic, such as overflow parking areas and service roads or fire lanes. Gravel surfaces are generally not recommended for pedestrian paths, because they can be difficult for older pedestrians or handicapped individuals to negotiate. The effectiveness of gravel-surfaced areas in infiltrating rainfall is variable and depends primarily on the contribution of fine particles to the mix. Only open-graded mixtures that contain very few fines will be associated with high surface infiltration rates. Dense graded road aggregate, which is commonly used to surface roads, is not appreciably more pervious than conventional paving. As appropriate, the surface gravel course may consist of decorative materials such as pea gravel or slag.

Unlike areas surfaced with payers or porous bituminous concrete, sweeping or washing of graveled areas is impractical. Therefore, gravel-surfaced areas are more prone to clogging by sediment. In particular, fine sediment tends to become incorporated in the loose gravel or stone in the uppermost layer of the paving. Penetration of sediment into the base can be prevented by separating the surface course and base layers with a geotextile. The upper surface of the paving may need to he scraped off and replaced with fresh material to restore the functioning of graveled surfaces if the surface infiltration rate decreases significantly. The longevity of gravel surfaces is gene rally shorter than for other types of pervious paving in the same setting.

Flexible Synthetic Webbing or Gridwork

There are several products available that utilize flexible, accordion webbing of plastic compounds that are laid down, spread out, filled with sand-soil mix and planted. Not a great deal is known about these materials at this writing, although they appear promising and may be considered by the Department.

Considerations

To prevent clogging, pervious paving should not be installed until all disturbed areas tributary to the paving have been completely stabilized. If subsequent disturbance of tributary areas occurs, runoff must be diverted around the paved site. The risk of premature clogging can be minimized only if care is exercised to keep sediment off the paving during and after construction.

In many instances, it is convenient to discharge roof downspouts directly onto pervious pavings. With this approach, the depth of the paving base must be increased to accept the additional runoff volume. For greater efficiency, downspouts can be interconnected to the base. However, this will require that a method of straining leaves and other roof litter is included, for example, vegetated roof covers.

Pervious paving should be installed on a shallow grade, which allows free drainage. Intentionally ponding stormwater on top of pervious paving by using curbs or embankments should be avoided. In addition to being a nuisance to pedestrians, ponding water promotes the settling out of fine suspended solids, which may infiltrate into the paving arid cause clogging.
Pervious paving can be constructed with a perimeter overflow edge. The edge will intercept runoff from the paving, if for any reason the pervious surface were to become clogged. The perimeter overflow edges connect directly into the base layer of the paving.

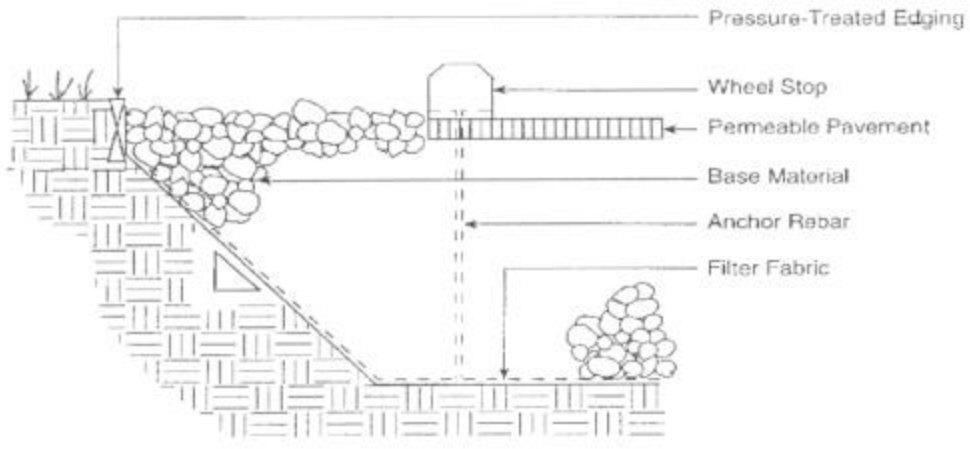

Figure 2. Perimeter overflow edge (adapted from Cahill Associates).

Figure 4. Perimeter Overflow Edge Source: Cahill Assoc.

This Standard has been adapted from: the Pennsylvania Handbook of Best Management Practices for Developing Areas, 1998. Pennsylvania Association of Conservation Districts; Pennsylvania Department of Environmental Protection. Harrisburg, PA.

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